Co-pyrolysis and Co-gasification of polyethylene and sawdust mixtures in a fluidised bed reactor; Temperature influence

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Co-pyrolysis and Co-gasification of high density polyethylene (HDPE) and sawdust mixture in a fluidised bed reactor were performed. The influence of the temperature on the products distribution and gas composition was investigated. Experiments at five different temperatures: 640, 680, 730, 780 and 850ºC were carried out for both processes. The polyethylene and sawdust were feed continuously into the bed using a nitrogen or air+nitrogen flow used as carrier gas and as fluidising agent. Silica sand of 350 ?m was used as material bed. The minimum fluidisation velocity of silica sand was 3.2 cm/s. The HDPE was then mixed with the sawdust in a ratio of 1:1 approximately, and a feed rate between 60 and 170 g/h was used. The reactor, constructed of stainless steel, was 4.8 cm diameter x 23 cm high. It was heated externally by a electrical furnace. The yields and composition of the derived oil, wax, and gases were determined. The H_2, CH_4, N_2 and C_2H_x to C_6H_x compounds on the gas produced were analysed by gas chromatography. Waxes and oils were analysed using Mass Spectrometry Gas Chromatography.

The co-pyrolysis experiments were carried out using nitrogen as carrier gas and as fluidising agent, to enable the bed operate in the range from 4.5 to 7 times the minimum fluidisation velocity, the residence time of the gas in the reactor had values between 1.7 to 1 seconds at the gasification temperatures. HDPE and sawdust flow varied from 110 to 160 g/h. At low temperatures, in the range of 640 to 700ºC, the main products were wax and gas. For higher temperatures the products were oils and gas. In the temperature range between 640 and 850ºC, the results showed a wide range of differing product yields: 55 to 90 wt % in gas and between 42 wt % in waxes and 8 wt % in oils. The main gases produced from the co-pyrolysis process were, at low temperature, carbon monoxide, ethylene, carbon dioxide, propylene, butadiene, methane and pentadiene, while at high temperature the gas composition changed drastically, the main gas being carbon monoxide (more than 33 wt %), ethylene, methane, benzene and hydrogen. The highest heating value of gas was obtained at 780ºC, the values being 13 000 kJ/Nm^3 and 28 300 kJ/kg of mixture.

The co-gasification experiments were performed using air or mixtures of air+nitrogen as a carrier gas and as fluidising agent. The air flow was calculated to obtain an air factor in the range of 10 to 15 % of the stoichiometric mixture combustion. The range of fluidisation velocity and the flow of HDPE and sawdust were very similar to co-pyrolysis process in order to compare both processes. The results showed that in the whole range of temperatures from 640 to 850ºC, the product were oils and gases. The highest oils yield (28 wt %) was obtained at 640ºC. The highest gas products yield (94.5 wt %) was obtained at 850ºC. The main gases produced from the co-gasification process were, at low temperatures, carbon dioxide, carbon monoxide, ethylene, propylene, butadiene, and methane. At high temperature the gas composition varied and the main gases were, carbon monoxide (more than 55 wt %), ethylene, methane, carbon dioxide benzene and hydrogen. The highest heating value of gas was obtained at 780ºC and the values being, 14 200 kJ/Nm^3 and 32 600 kJ/kg of mixture.

In both processes, the HDPE and sawdust primary decomposition, the secondary reaction and wax cracking reaction take place inside the reactor and cyclone. The yields of more than 40 products (in gas and oils or waxes) were analysed as a function of the operating conditions. Higher gas yields and heating values were observed in the co-gasification process than in co-pyrolysis. The presence of oxygen in the co-gasification increased the cracking rate of the higher molecular weight compounds. In general, at low temperature the oils fraction gave a mainly aliphatic composition consisting of a series of alkanes, alkenes and alkadienes. At high temperatures (780 to 850ºC) the oils fraction consisted of mainly aromatic compounds (benzene, xilene, indene and naphthalene).

The results obtained in co-gasification and co-pyrolysis with HDPE and saw dust mixtures did not show a synergistic effect when compared with the results obtained in pyrolysis and gasification of this combustible separately.

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